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Technical Lesson 51

BATTERY ELIMINATORS

Alternating current cannot be used for charging storage batteries, nor can it be used to supply power to radio receiving tubes unless it is changed from an alternating to a direct current form. Changing alternating current to direct current is called "rectification". Battery eliminators are devices designed for the purpose of doing away with batteries. Eliminators are classed: (A) Alternating current type (B) Direct current type.

Type A is designed for operation on 105-125 volts, 50 to 75 cycles; 105-125 volts, 25-50 cycles; and 220 volts, 50-60 cycles.

No attempt should be made to operate an eliminator made for alternating current on a direct current circuit, nor on an alternating current source of a voltage or frequency different from that specified by the manufacturers of the particular device to be used.

The eliminator is used principally for supplying power to the plates of the receiving tubes, and for biasing the grids.

The alternating current model is by far the most widely used. This is so because direct current systems are only found, as a rule, in small sections of the larger cities, and because of the comparatively simple manner in which alternating current can be transformed from the existing voltage of the line to one suitable for operating the modern receiver, some of which require as high as 300 volts for plate excitation.

Type B is designed for operation from a direct current supply only and will be taken up later in this lesson.

The first of the two types to be discussed is the alternating current model. Alternating current, as you know, derives its name from the fact that its polarity reverses a definite number of times each second. Each of these reversals are called alternations, and two alternations are expressed as one cycle. Whenever you hear the expression "110 volts 60 cycle system", you will know it means that the power in the electrical system has an electrical pressure, i.e., potential of 110 volts, and it alternately becomes positive and negative 60 times in each second, which means that the current reverses its direction 120 times a second.

Power of this nature could not be properly applied to a radio receiver designed for direct current operation because of a steady 60 cycle hum which would be heard in the loudspeaker caused by the constantly changing value of the current as shown in Figure 1.

For this reason a rectifying device is incorporated in the eliminator, the function of which is to change the form of the current in such a way that it does not reverse its direction but leaves the rectifier in the form of a unidirectional pulsating current as shown in Figure 2; the current in this form is still unfitted for use because of the rapid changes in each pulse of current. A filter system is therefore necessary to smooth it out into a direct current as shown graphically in Figure 3. The "B" power eliminator, if properly designed, will furnish a steady unfluctuating current without any objectional hum.

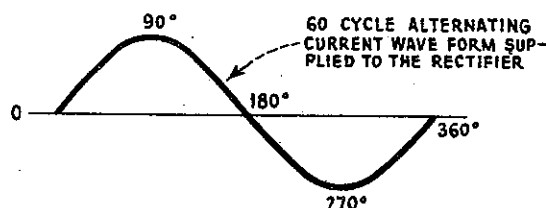


Figure 1

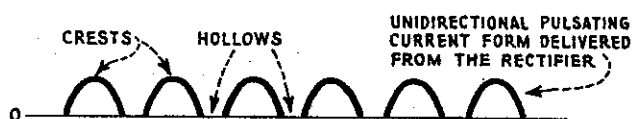


Figure 2

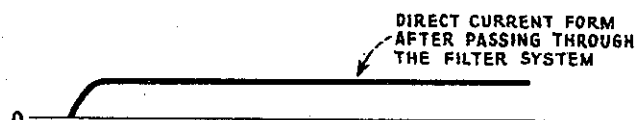


Figure 3

To be able to thoroughly understand the operation of a power unit of this kind it is best to divide the entire unit into four main parts, and study each part separately by following the schematic diagram of Figure 4.

The first part of every alternating current eliminator is the power transformer which takes the required power from the house lighting circuit and steps it up to a value sufficiently high to overcome the losses in the system and leave available adequate power to efficiently operate the receiver. Connected to the secondary terminals of the transformer is the second part of the power unit, the rectifying device, which may be one of five types, (1) the filament type which utilizes the electron stream between the heated filament and the plate to obtain one way conductivity; (2) the gaseous non-filament type which makes use of the ionization of a gas at low pressure between the electrodes of the tube to effect rectification; (3) the electrolytic type; (4) the dry metallic type and (5) the vibrating mechanical type. These rectifying devices serve to change the alternating current output of the transformer to a pulsating unidirectional current which must still undergo a further change in form before it can be applied to the receiver. It is therefore passed on to the third part of the system, the filter, which smooths out this pulsating unidirectional current to a smooth continuous direct current

The direct current, after passing the filter system, may be of the correct voltage for the power tube used in the last audio frequency stage but must be passed on to the fourth part, the voltage regulator, which consists

of resistances of various values used to reduce the voltage to the proper values for the detector, the radio-frequency amplifying tube, and the audio-frequency amplifying tube (with the exception of the power tube.)

Rectifier tubes: As previously stated there are two types of rectifier tubes, one employing a filament, often called the hot cathode type, and the other which has no filament and is known as the gaseous rectifier.

Before going further we should understand the meaning of the words cathode and anode. Cathode means a negative electrode; anode a positive electrode. Both of these words are often found in radio literature; for example, cathod refers to the filament of a vacuum tube to distinguish it from the plate or anode.

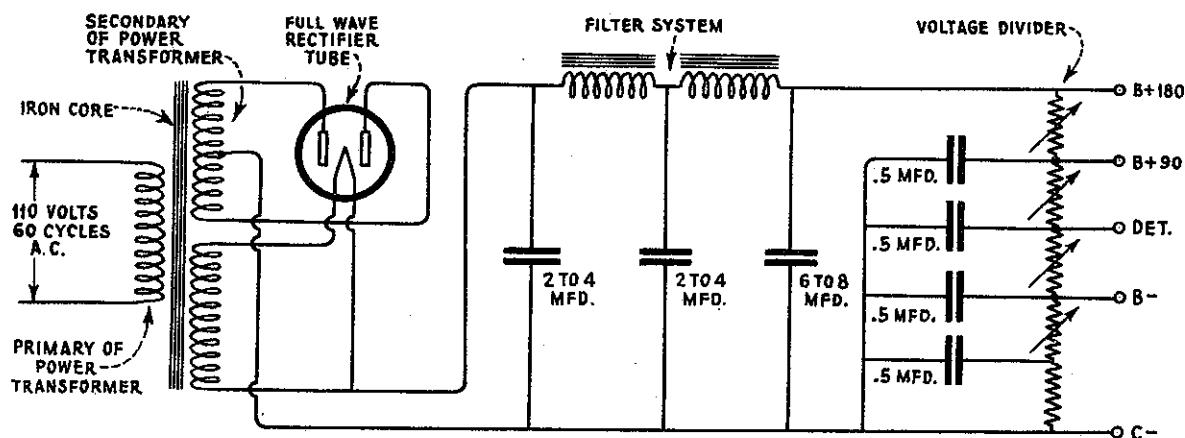


Figure 4

When discussing the gaseous rectifier, Anode is the name given to the two small electrodes, while the Cathode applies to the single large electrode.

The filament type rectifier tube functions as a rectifier due to the property of the heated filament to emit; that is, throw off electrons which move in one direction, toward the plate. The two plates in the full wave rectifier tube are connected to opposite ends of the secondary winding of the power transformer and has alternately impressed on them a positive and negative charge by the alternating current cycle; that is, during the time that one of the plates is charged positive by one half of the alternating current cycle, the other plate will be charged negative. A reversal of this action takes place on the next half cycle.

During each cycle one of the plates is positive for one alternation and this same plate becomes negative the next alternation; this action reverses each alternation and the plate which was positive during the first alternation now becomes negative and the previously negative plate becomes positive. The electrons emitted from the filament pass to the positively charged plate and are repelled by the negatively charged plate. In this way both halves of the cycle of alternating current are utilized to produce a unidirectional current in the output circuit of the rectifier.

A half wave rectifier operates upon the same principle as described for full wave rectification with the exception that only one half of the cycle is utilized. Figure 5 shows the connections for this type of filament rectifier tube.

Gaseous rectifier: The gaseous tube rectifier has no filament; its action depends upon a gas content which, upon being ionized, permits a current to flow through the gas. A circuit adapted for this tube is shown in Figure 6. The tube has two small electrodes and one large one. The small electrodes are connected to opposite ends of the power transformer secondary terminals while the large electrode connects to the external circuit, and the space between the electrodes is filled with helium (an inert gas) at low pressure.

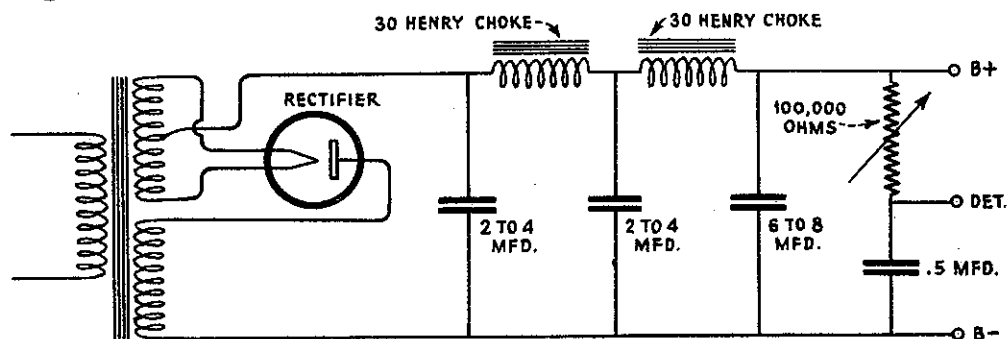


Figure 5

The action of the gaseous tube: Perhaps you have seen an Xray machine in operation. You observed the soft purple glow emitted by the tube. This subdued light was caused by what is known as IONIZATION. Ionization is the splitting up or separating of electrons from an atom and may apply either to a gas, chemical solution, or chemical compound.

All atoms, when in a normal stage, manifest no unusual electrical characteristics but if by some means an electron is taken away from or added to a normal atom then electrical properties of the atom so changed are exhibited by attractive and repulsive effects. The atom is then said to be ionized.

Therefore when a normal atom for any reason takes on an additional electron,

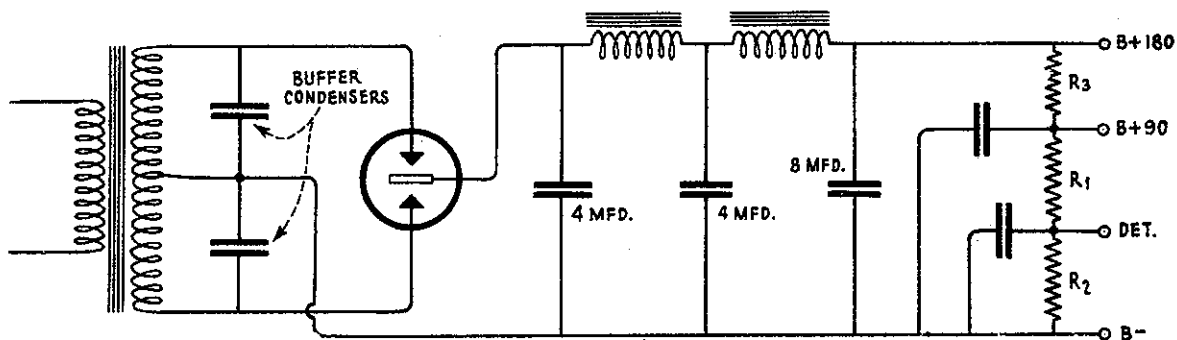


Figure 6

or an electron is caused to leave a normal atom, the particle thus formed by the first condition is called a "negative ion" and by the second condition a "positive ion." This process as a whole is termed "ionization".

The small gas content in a rectifier tube represents billions and billions of atoms. They are continually on the move; their movement is similar to so many rubber balls dumped into a confined space all taking haphazard paths in their line of flight, but of course the atoms move at tremendously high speeds.

For many years it was known that gas, under certain treatment, possessed the property of being an insulator and then, under other conditions, it would become a perfect conductor. This phenomenon was for many years a mystery. The constant research work by the physicist to learn more about matter has, however, disclosed many wonderful things and the study of ions, electrons, and atoms, which constitute matter, is a very important one.

In connection with the gaseous rectifier it was found that when a high potential exists between either of the small electrodes and the large electrode of the gaseous tube it would cause the gas atoms to be set into violent agitation sending them in every conceivable direction and at terrific speeds, bumping into each other with such force that each time a collision between the atoms occurred an electron would be knocked free, and thus ionization of the gas was accomplished.

The gas atom on losing an electron becomes positively charged and is often termed a POSITIVE ION. As a result, then, of ionization the previously normal atom now shows electrical characteristics and since it is minus its regular complement of electrons it at once seeks the cathode element where it takes on an electron thus completing its balance only to be crashed into again by some neighboring atom and reionized, upon which it again returns to the cathode to acquire another electron. This action takes place over and over again. The electrons released by the collisions at once seek a positively charged electrode. It is these released electrons that act as carriers of electricity thus creating a flow of electricity from cathode to anode and thence through the external circuit. If the cathode and anodes were made the same size current would flow as well in one direction as in the other which would defeat the purpose of rectification, but by making the two anodes very small in comparison with the cathode the positive ion may easily come in contact with one electrode and pick up its required electron; but with the potential reversed their ability to strike the small electrode is greatly diminished and, in their attempt to make contact with this small electrode, they pile up a positive charge which tends to repel any further positive ions attempting to reach this electrode. A few electrons, because of their terrific speed, manage to force their way through this positive charge and cause a small back current to be set up. For all practical purposes, however, this is so minute that we may consider it as negligible.

Filter system: Having a rectified current now to deal with, but pulsating in form, refer to Figure 2. We will direct our attention to the third part of the eliminator unit whose function is to take the "humps" out of the pulsating unidirectional current and change it to a smooth direct

current. The third part of the eliminator, shown in Figure 4, is seen to consist of choke coils and condensers.

The filter system, as shown in the diagrams of this lesson is practically universal in use and is known as the "brute force filter". Figure 7 shows one adaption of this filter, known as the single filter, while Figure 8 illustrates the double type which is simply two choke coils in series, and an additional condenser.

Practically all filter systems are built up according to the latter classification. The value of the choke coil is in practically all cases 15 to 30 henrys while the values of the condensers may vary depending upon the type of eliminator used. C1 can be any value from 2 to 4 mfd. capacity; C2 the same as C1, and C3 from 6 to 8 mfd. capacity.

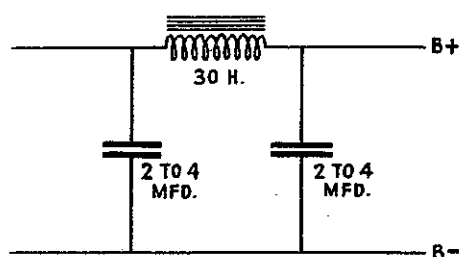


Figure 7

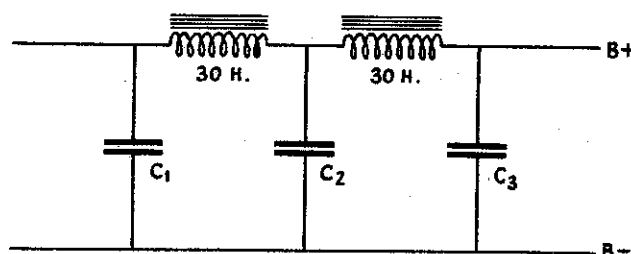


Figure 8

Let us study the function of the filter system to learn the purpose of each part. It has been previously stated that the rectifying device changes the alternating current to a unidirectional pulsating current which is still in such form that it cannot be applied directly to the tube elements of the receiver. If we refer to Figure 2 we find that this pulsating current consists of a number of pulses of current rising from zero value to a maximum strength and then falling again to zero, then a short interval of time elapses before the next pulse of current comes along. These pulses of current, as they come from the rectifier tube, are as varied in magnitude as the varying magnitude of the A.C. producing them. It, therefore, can be realized that a current having such variable characteristics cannot be directly applied to the plates of vacuum tubes without producing an effect which is called "ripple" or "hum".

We know that the plate of the vacuum tube must have a source of constant potential applied to it, such as would be obtained from a battery. The entire filter system, then, is designed to give us a source of potential just as closely paralleling that which would be obtained from a battery as can be had, and in order to have that form of energy from a widely varying pulsating current our filter system must perform certain functions.

When a current changing in value is passed through the choke coils an electromagnetic field is set up about the windings of the coils and tends to prevent any change in the current flowing through it. Now right here is where condenser C1 of Figure 8 begins to work. The current, being

opposed by the choke coil, finds in condenser C1 what might be called a reservoir into which it flows, storing up until a change takes place that will permit its return to the circuit. This change takes place just as soon as the pulse of current has reached its maximum or peak value.

The lines of force which were built up about the choke coil during the rise in value of the pulse of current now collapse on the choke coil windings and this time they tend to promote current flow. Condenser C1 now gives up to the circuit the current it stored during the increase of the current pulse, thus tending to continue the current flow on the circuit after the pulse from the rectifier has decreased to zero. Condenser C1 then acts as a reservoir absorbing energy during the rise of the current wave and returning it to the circuit at the lower values of the decreasing current wave, thus tending to maintain a more nearly constant flow of current irrespective of varying load conditions.

Condenser C2 also goes through a process of storing and releasing energy but its chief function is to suppress any remaining current variations, thus eliminating the hum by a further smoothing out of the current as passed to it from the first choke and condenser C1. In practice it has been found that the circuit functions best when both C1 and C2 are made equal in value.

Condenser C3 is a third electrical storage house and functions to supply the receiver with additional energy when required; for example, when a frequency which produces the bass notes of the lower register passes through the tubes more plate current is necessary to faithfully reproduce such notes. Condenser C3 therefore functions at this part of the work and supplies the required energy. We have, then, in the filter system a device which changes the widely fluctuating unidirectional pulses into a smooth direct current and also stores up energy to be released into the circuit as it is required.

By means of the filter, the third part of the eliminator, we now have D.C. at a voltage sufficiently high to operate a power tube which requires the greatest plate energy of any tube employed in the receiver. This energy, however, is too great to be supplied to the radio-frequency tubes, the detector, and possibly the first audio-frequency tube.

This brings us to the fourth part of the eliminator circuit, a part known as the voltage divider, which is shown in Figure 4. This part of the unit is simply a series of resistance units connected across the output of the filter circuit with taps taken off at the proper places, thus utilizing the voltage drop across the correct amount of resistance to be applied to the plates of the tubes in the receiver. The voltage divider can be one continuous winding of resistance wire with taps taken off at various points, or adjustable resistors may take the place of fixed resistor units, thus making possible a close adjustment of the voltages required.

The value of these resistors is dependent upon the current required by the tubes they supply. Values of the various resistors are shown in Figure 6. Resistor R1 may be an adjustable resistor having a range from

10,000 to 100,000 ohms, R2 may be approximately 10,000 ohms, while R3 may be a variable resistor having a range from 2,000 to 10,000 ohms resistance.

Direct Current Eliminators

Where direct current is available as a source of power, the eliminator problem is greatly simplified as there is no power transformer involved in the circuit and the eliminator comprises simply a filter circuit, the function of which is to eliminate the commutator ripple of the direct current generator supplying the line from which the eliminator power is taken. The voltage divider operates on the same principle as in any type of Eliminator.

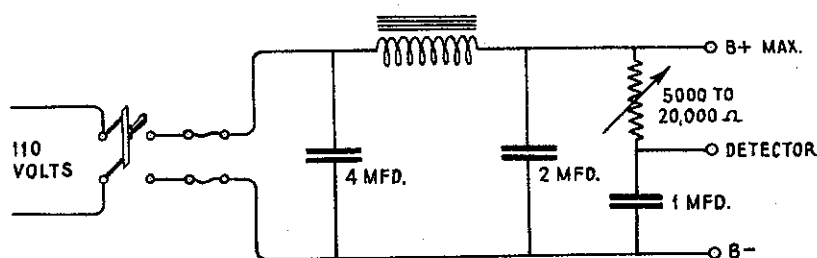


Figure 9

An eliminator circuit for supplying plate potential only is shown in Figure 9; approximately 90 volts is the maximum voltage obtainable due to the losses in the filter circuit, the greatest loss of voltage occurring in the choke coil. If more than 90 volts is required, 45 volt "B" battery blocks may be connected in the positive leg of the circuit as shown in Figure 10.

Figure 10 shows a direct current eliminator designed for "A" and "B" power. Since the device is operating from a direct current line of 110 volts the losses of the system will reduce the available voltage at point B + to approximately 90 or 100 volts, therefore if more voltage is required it is a simple matter to connect 45 volt heavy duty "B" battery block units in the positive side of the output until the value required

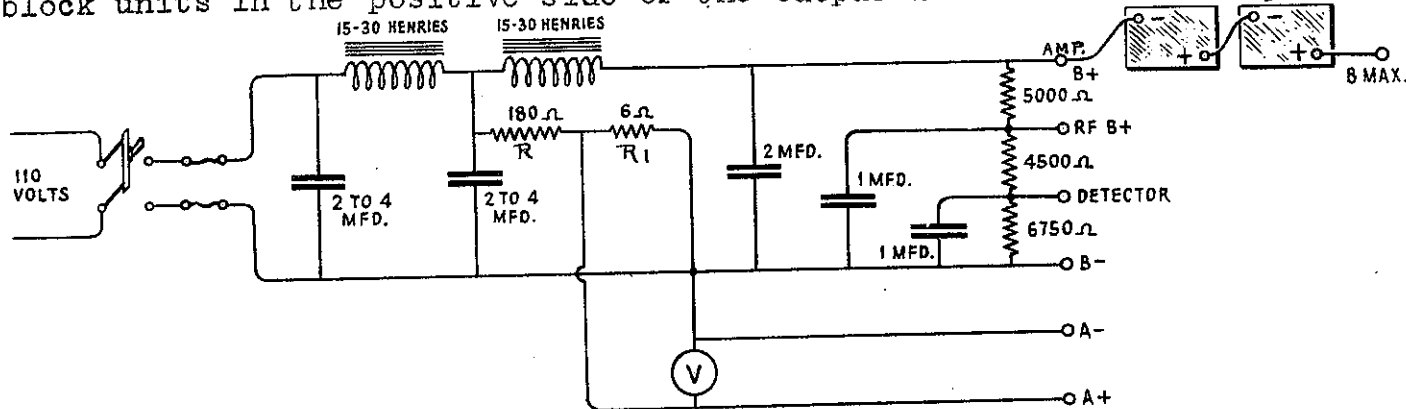


Figure 10

to operate the tube used in the power stage is reached.

The values of the resistances R and R1 will depend upon the total amount of current in amperes that the tube filaments of the set draw, and then use the proper resistance in ohms. For five UX 201A type tubes the values given are correct. Place a voltmeter across the "A" source as shown; if it reads over 5 volts adjust R and R1 until 5 volts is read.

The precautions when using this type of eliminator are: (1) Always connect a fixed condenser having a capacity value of at least 0.5 mfd. in series with the ground lead of the receiver. (2) Make sure the antenna is free from any possibility of grounding. (3) See that all the tubes are properly seated in the sockets. (4) Do not remove a tube from its socket until after the filament switch of the set has been opened.

Chemical Rectifier

The chemical, or electrolytic rectifier, is one that employs a chemical solution in which two dissimilar metals are immersed. One of these metals acts as a conductor to bring the current in contact with the chemical solution (electrolyte); the other metal is called the "valve metal" because it allows current to pass in one direction only. There are a number of metals suitable as a valve electrode, a few of which are aluminum, tungsten, magnesium and bismuth. The other electrode may be any inert metal which is not subject to attack by the electrolyte, for example, lead or iron. The lead electrode has no part in the rectification action other than offering a means to lead the current into the electrolyte.

The electrode acting as the "valve electrode" is always connected to the positive side of the filter system when the rectifier is used for vacuum tube plate excitation. Where this type of rectifier is employed as a trickle charger the valve electrode is always connected to the positive terminal of the battery to be charged. The two metals most commonly employed are aluminum, which is the valve metal, and lead as the electrode to lead the current into the electrolyte. When aluminum and lead are used as the electrodes the electrolyte is made by dissolving ammonium phosphate, or common Borax, in distilled water, combining the crystals with the distilled water until the saturation point has been reached; the point of saturation is reached when the crystals will no longer dissolve and combine with the water. The solution should be mixed in an earthen ware container and, when thoroughly mixed, the clear liquid poured into the containers used as rectifier jars or cells.

It is very important that the water and the chemical used be pure; i.e., free from foreign substances. Impurities such as chlorine will, if combined with the water used in the electrolyte, retard the rectifying action and may stop it entirely. Since city water is in many instances treated with chlorine it should never be used. Distilled or filtered rain water only is the best to use in the electrolytic rectifier. The aluminum electrode should be pure aluminum. The commercial grade may prove satisfactory but in many instances it will not because of traces of copper which it may contain and which will cause the electrode to overheat. The jars should never be entirely enclosed; a free circulation of air around each jar is necessary to prevent the unit as a whole from overheating.

The principal upon which the electrolytic rectifier operates is by virtue of a film of bubbles which forms on the aluminum electrode (the valve metal in this instance). This film is an insulator and forms a dielectric between the aluminum plate and the electrolyte.

Since the aluminum and the electrolyte are both conductors a condenser effect is formed by the film, the insulating property of which is dependent upon the amount of gas covering the aluminum electrode. This film acting as the dielectric about the aluminum electrode prevents current from flowing through the device when the aluminum electrode is made positive by one half cycle of the alternating current. When the lead electrode is made positive by the next alternation the film does not form at either electrode thus allowing a free path for the current to flow.

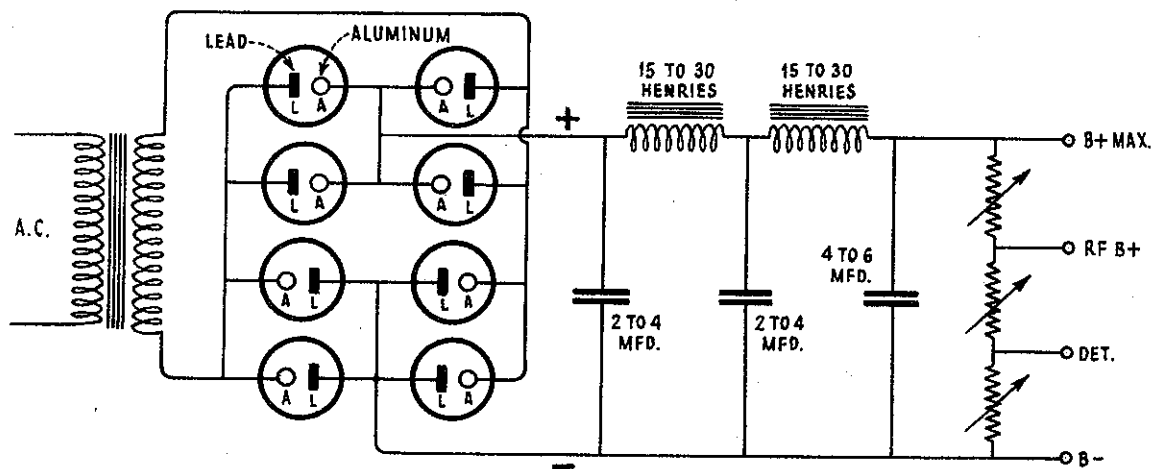


Figure 11

The advantage of the electrolytic rectifier lies in the fact that the voltage drop with an increase in load is less than other types of rectifiers due to the low internal resistance of the cells. It is objectionable, however, from the standpoint of its size and the care necessary for its up-keep.

Figure 11 shows an eight cell electrolytic rectifier unit with its associated filter system and voltage divider. The resistors of the voltage divider may be any of the commercial forms of variable resistances made for the work.

Metallic Rectifiers

The metallic contact rectifiers are different from all other types. They consist of a number of prepared plates of a special copper alloy which are pressed together hydraulically and then bolted to insure as near as possible a perfect close contact between the different plates. The theory of operation regarding this type of rectifier is based on certain phases of the electron theory.

In any body of metal there are a few electrons which are free to shift

about, the number able to change in position depending upon the metal. These free electrons move in an electronic field and may travel only a short distance from the surface of the metal and are then drawn back.

The theory of one way conductivity is based upon this electronic field produced by the different alloys used to make up the plates of the rectifier. If the electronic field of one is more dense than the other, electrons will pass with comparative ease toward the metal having the more dense or stronger field, while they will be prevented from reaching the plate having the less dense or weaker electronic field.

The actual passage of the electrons take place only at the junction point where the two electronic fields meet and, as the electron can move only an extremely short distance from the surface of the metal, perhaps less than a half millionth part of an inch, a perfect metallic contact must be maintained between the alloy plates.

The Vibrating Rectifier

The vibrating rectifier is a mechanical device for changing alternating

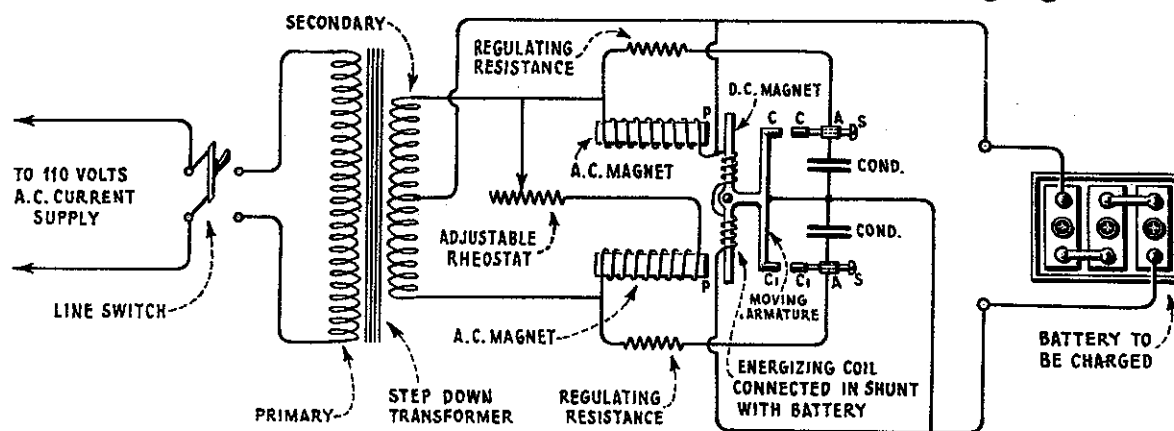


Figure 12

current to a unidirectional current for battery charging purposes. This type of charger is used principally for charging 6 and 12 volt storage "A" batteries.

A step down transformer, shown in Figure 12, is incorporated in the device for reducing the voltage of the house lighting system to a proper value. The transformer not only steps down the voltage but, by means of a center tap taken off the secondary winding, it provides a return for the rectified D.C. current.

When connected to the battery and with the line switch closed, the current flows from one end of the secondary winding of the transformer through the regulating resistance, through one set of contacts CC which close at the correct instant, thence to the center point of the moving armature from which it passes to the positive terminal of the battery under charge. This completes one alternation. During the next alternation of the cycle the voltage of the secondary winding is reversed; this time current flows

from the other half of the secondary winding through the regulating resistance to the other set of contacts C1 C1 to the center of the moving armature, and then to the positive terminal of the battery.

The efficient operation of this device is dependent upon a vibrating mechanism which opens and closes contacts CC and C1 C1 exactly in synchronism with the voltage reversals so that the current carrying circuit to the battery is opened at the time the current flow is zero.

The vibrating part of the system consists of a polarized relay which is caused to function by two alternating current magnets in such a manner that it moves backward and forward in step with the alternations of the current. The bar marked D.C. magnet is energized by a coil which is connected in shunt to the battery so that its polarity never changes. The two permanent electro-magnets shown as A.C. magnets are wound in such a way that the ends PP are of the same polarity at the same time. On one alternation the current flows through the A.C. magnet windings in one direction and, we will say, causes the ends PP to become of north polarity. With this condition existing the south end of the D.C. magnet will be

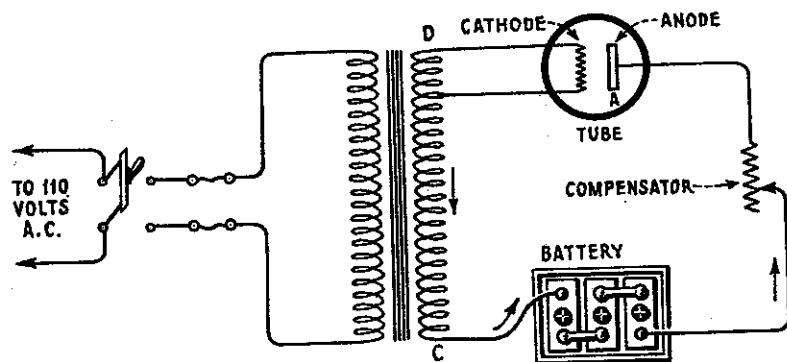


Figure 13

attracted to the A.C. magnets of north polarity and since the arm marked "moving armature" is rigidly secured at the center point of the D.C. magnet (one end of which has now been attracted toward the A.C. electromagnets) one set of contacts will close.

When the A.C. current reverses on the succeeding alternation both the A.C. electromagnet ends PP will become of south polarity and then the north end of the D.C. magnet will be attracted toward the permanent A.C. magnets, thus closing the other set of contacts secured to the moving armature. This will reverse the connection of the alternating current circuit to the direct current circuit, but the direction of current has also reversed therefore the current flows into the circuit supplying the battery as it did on the first alternation.

The contacts CC and C1 C1 are thus opened and closed each time the current reverses in direction and, because of this, a unidirectional pulsating current is continually fed into the battery in the proper direction. An adjustable resistance is provided and connected in series with the alternating current magnets so that exact timing for the opening of the direct

current carrying circuit is secured at the instant when the battery and transformer voltages are opposite and equal and no current flowing. This tends to insure a minimum amount of sparking at the contact points.

The condensers are connected across the contacts to further assist in reducing the sparking at the contact surfaces due to a variation in the line voltage.

The Hot Cathode Gas Filled Rectifier

Figure 13 shows the connections of a half wave rectifier in which is employed the "hot cathode type rectifier". It consists of the tube with cathode and anode. The cathode consists of a filament of small tungsten

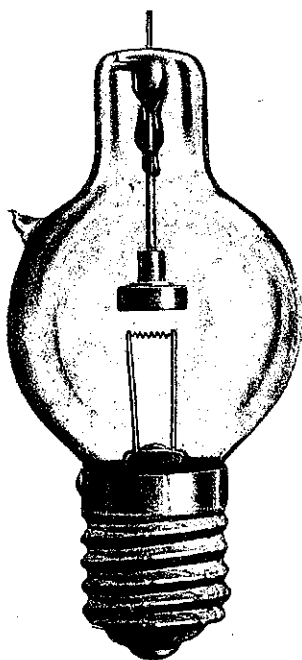


Figure 14

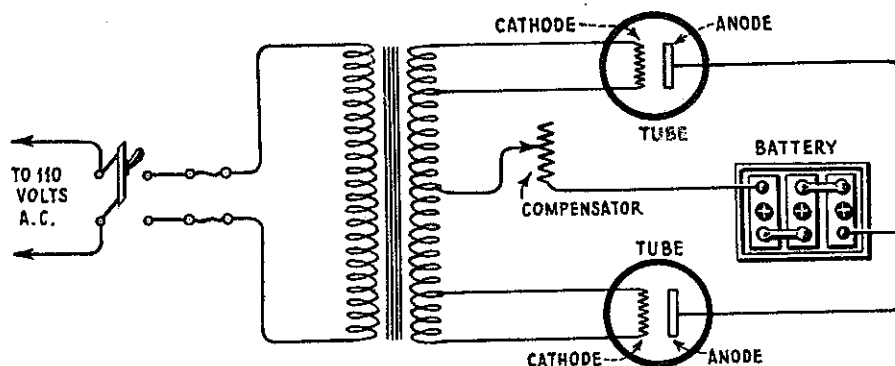


Figure 15

wire coiled into a closely wound spiral, while the anode is a plate made of graphite which is secured to a rod by means of a screw thread.

A transformer and a compensator, with which is combined the filament transformer and reactance, is also a part of this rectifier unit. The compensator is illustrated in the drawing as an adjustable resistance. This resistance is not actually used in practice, but we have shown it in place of the compensator for the purpose of simplifying the drawing. An illustration of the rectifying tube is shown in Figure 14. When full wave rectification is desired the circuit shown in Figure 15, which is in simple form, is employed.

For a number of years scientists have known that a vacuum tube containing a hot and a cold electrode functions as a rectifier and it was from these principles that the Tungar Hot Cathode gas filled rectifier was developed.

A vacuum is created in the glass envelop containing the Cathode and Anode

and then a small quantity of inert gas (Argon), at low pressure, is introduced. The name "Argon" comes from the Greek, meaning lazy or inactive, because it combines with no other element.

Electrons are emitted from the cathode when it is heated to incandescence, ionizing the argon gas particles which in this state acts as the principal current carrier. Rectification takes place because, on the half cycle, when the graphite anode is positive the electrons emitted from the incandescent cathode are being drawn toward the Anode due to the voltage impressed across the anode and cathode by the secondary of the transformer. The electrons collide with the gas molecules and ionize them; that is, make them conductive in the direction of Anode to Cathode.

During the other half cycle when the Anode is negative, electrons that are emitted are forced back to the filament so that the gas does not form a conducting path during that half cycle.

Assume, for example, that side C, Figure 13, of the alternating current supply is positive, the current then follows the direction of the arrows through the battery being charged, through the compensator, shown as a rheostat in the Figure, to the Anode, across the vacuum made possible by the ionized gas, to the cathode and thence returns to the opposite side of the alternating current line.

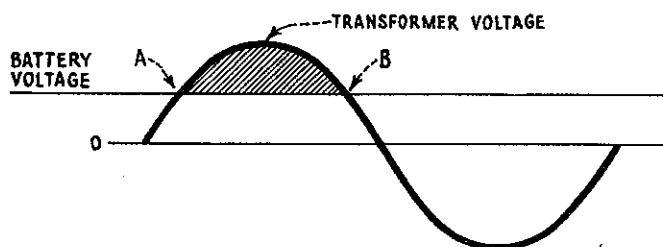


Figure 16

Now the alternating current supply reverses and the side D becomes positive; the current will be prevented from flowing because any electrons emitted are now yanked back to the cathode so that the gas in the tube is non-conductive during this interval.

From the foregoing we see that the current is allowed to pass from the Anode to the Cathode during one alternation of each cycle and thence to the external circuit.

The principle on which the storage battery is charged from this type of rectifier is graphically shown in Figure 16. The illustration shows one cycle of half wave rectification.

During the upper half of the cycle, when the transformer voltage exceeds the battery voltage, point A, the Anode of the tube becomes positive making the tube conductive and the charging current flows through the battery. When the transformer voltage drops below the battery voltage, point B, the tube is no longer conductive and the charging current ceases

on the lower half of the alternation. The transformer voltage adds to the battery voltage and since the Anode does not become positive, the tube cannot conduct current.

A rectifier; then, is a device for converting alternating current to unidirectional current.

The full wave rectifier utilizes both alternations of the alternating current cycle. Both the positive and negative impulse of the cycle pass through the rectifier.

The half wave rectifier rectifies only one of the alternations, therefore only one impulse of current passes through it for each full cycle of alternating current. The other alternation is not lost but simply prevented from passing through the rectifier to the output circuit.

EXAMINATION - LESSON 51

1. Name two types of eliminators.
2. Why are alternating current eliminators in greater demand than D.C. types?
3. What is the function of the transformer in an eliminator?
4. Name four types of rectifiers.
5. What is meant by the term (a) Cathode? (b) Anode?
6. What gas is employed in the gaseous rectifier?
7. What name is given (a) an Atom which is minus an electron (b) one which has taken on an additional electron?
8. Of what use is a filter system?
9. Is the voltage divider necessary?
10. Name two types of battery chargers.